

REMARKS/ARGUMENTS

This Reply is in response to the Final Office Action dated June 3, 2004 and is accompanied by a petition for a two-month extension of time, a request for continued examination (RCE), and an authorization to charge the small entity extension and RCE fee Deposit Account No. 50-0951.

Claims 1-26 and 29-48 were pending at the time of the Final Office Action. All claims were rejected. In this Reply, claims 1-5, 9, 10, 22-24, 26 and 29 have been amended and claims 7, 11-16, and 38-48 have been cancelled. No new matter has been added.

In the Final Office Action claims 11-16 and 38-48 were rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. Although Applicants respectfully disagree with the Examiner's determination of indefiniteness, claims 11-16 and 38-48 have been cancelled. Accordingly, the 35 U.S.C. 112, second paragraph rejections are now overcome.

In Applicants' Reply to Office Action filed on March 1, 2004, claim 1 was amended to recite a minimum range of selective adsorption additive (e.g. surfactant) concentrations. Although Applicants' claimed recited minimum concentrations are above the maximum concentration disclosed in the cited references, including Kaufman (US 5,954,997), the claims were still rejected as being obvious.

Specifically, claims 1-16, 18-23 and 31-48 are rejected under 35 U.S.C. 103(a) as being unpatentable over previously cited Kaufman (US 5,954,997) as applied to claim 1, and further in view of Yano et al. (US 6,454,819 B1). Yano is cited by the Examiner as teaching a slurry including an organic solvent. Claim 17 is rejected under 35 U.S.C. 103(a) as being unpatentable over Kaufman (US 5,954,997) as applied to claim 1, and further in view of Yano (US 6,545,819

B1). Claims 24-26, 29, and 30 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kaufman (US 5,954,997) as applied to claim 1, and further in view of Wake et al. (US 6,436,811).

In response, Applicants have amended claim 1 to now recite a slurry having novel particles to clearly distinguish the claimed invention over the cited art, and have moved the selective absorption limitation to dependent claim 2. As amended, claim 1 recites a slurry for chemical mechanical polishing (CMP) of a structure including a refractory metal based barrier film and a dielectric film, comprising a bulk solution, a plurality of particles, wherein the particles comprise nanoporous particles, composite particles formed from a first solid material coated with a second solid material, the second solid material being different from the first material, or two phase composite particle where a first solid material phase is blended with a second solid material phase different from the first material phase. Such particles are described in Applicants' application in several places, including Figs. 4 and 5 and the associated detailed description. For example, Fig. 4(b) shows a composite particle formed from a first solid material coated with a second solid material, the second solid material different from the first material, Fig. 4(d) shows a two phase composite particle where a first solid material phase is blended with a second solid material phase different from the first material phase, while Fig. 4(e) shows a nanoporous particles. Regarding the composite particles formed from a first solid material coated with a second solid material, the second solid material being different from the first material, Fig. 5(a) shows an alumina particle coated with silica, while Figs. 5(b) and 5(c) show examples of a silica particle coated with a nano-porous silica material and silica particle coated with cerium oxide, respectively.

Regarding the first of the three recited novel slurry particle types, nanoporous particles, former claim 6 which recited nanoporous particles was rejected based on assertions made on page 6 of the Office Action relating to surfactant coated metal oxide particles. Applicants respectfully note that surfactant coated metal oxide particles have no relation to the claimed nanoporous particles which by definition have nanoscale pores. The claimed nanoporous slurry particles provide unexpected and highly advantageous results, particularly when used in conjunction with Applicant's selective adsorption additive comprising slurry.

In this arrangement, because of the porous structure of the particle surface, the adsorption of surfactants or polymer additives can occur at different, and generally lower, concentrations as compared to bulk particles.

Regarding the second of the three recited novel slurry particle types, composite particles formed from a first solid material coated with a second solid material, the second solid material different from the first material, Applicants note that the recited limitation of solid on another solid is clearly distinct from the surfactant (liquid) coated metal oxide particles previously cited by the Examiner. As described in paragraph 96 of the application, copied below, the unique characteristics provided by such composite particles can provide superior polishing results:

The cores of the composite particles can be selected to achieve desired mechanical, surface chemical and selective adsorption additive (surfactant or polymer) adsorption characteristics, respectively. For example, if a particular hardness and surface characteristic is desired, the inorganic core can be composed of a hard core, such as alumina, silicon nitride, and coated with a thin layer, such as silicon dioxide, low K dielectric or a non-soluble polymer, which mimics the composition of the dielectric layer. Thus, particles with specific desired mechanical and additive adsorption properties can be obtained. The mechanical properties of the composite particles are primarily controlled by the properties of the bulk material comprising the core, but the surfactant adsorption properties are controlled by the coated layer on the surface of the core particle.

Regarding the third of the three recited novel slurry particle types, two phase composite particles comprise a first solid material phase blended with a second solid material phase

different from the first material phase. Again, such a blended arrangement is clearly distinct from the surfactant (liquid) coated metal oxide particles previously cited by the Examiner.

Accordingly, Applicants submit that the slurry recited in amended claim 1 is patentable over the cited art.

Regarding the selective adsorption additive limitation now recited in claim 2, Applicant notes that the recited minimum concentrations are distinct and non-obvious based on the cited art. Specifically, the recited selective adsorption additive concentration in amended claim 2 is from 6 to 1,000 critical micelle concentration (CMC) when the selective adsorption additive is non-ionic (uncharged), and from 1 to 1,000 CMC when the selective adsorption additive is zwitterionic, anionic or cationic (charged). The recited minimum concentration in then claimed range is sufficient for the selective adsorption additive to self assemble (thus forming micelles) in the bulk solution (> 1 CMC) provided by the claimed slurry.

As noted in Applicants' March 1, 2004 Reply, use of a slurry having a surfactant concentration sufficient for self assembly to occur provides an unexpected increase in CMP selectivity:

The proportion of molecules present at the surface or as micelles in the bulk of the liquid depends on the concentration of the amphiphile. At low concentrations surfactants will favor arrangement on the surface. As the surface becomes crowded with surfactant more molecules will arrange into micelles. At some concentration the surface becomes completely loaded with surfactant and any further additions must arrange as micelles. This concentration is called the *Critical Micelle Concentration (CMC)*.

When the surfactant concentration in the slurry is above some threshold level above 1 CMC, some layers will experience substantial adsorption where the CMP polishing rate (for a given slurry and CMP polishing conditions) without the adsorption additive is substantially more (e.g. at least 4 times or more) than the CMP polishing rate when the slurry includes the adsorption additive/additives. On the other hand, other layers will experience non-substantial adsorption relative to a given film without the adsorption additive being substantially less (e.g. less than 4 times) than the polishing rate of the layer when the slurry includes the selective adsorption additive/additives. As a result, the polishing selectivity and resulting planarity provided by Applicants' claimed slurry is significantly improved over conventional slurries.

Regarding the rejection of claims 1-16, 18-23 and 31-48 based on Kaufman in view of Yano appears to be an error because Kaufman is relied on alone for rejection of these claims. Even though former claim 1 (current claim 2) recites a minimum selective adsorption additive concentration range which is above the upper limit disclosed by Kaufman and sufficient so that the selective adsorption additive self assembles in the bulk slurry solution, the Examiner asserts that the claimed range is obvious. According to the Examiner:

It is acknowledged that Kaufman teaches the limitations of the claimed invention but fails to specify concentrations of the adsorption additive and core particles; and the selectivity of CMP. However, it would have been obvious to one of ordinary skill in the art at the time the invention was made to select any specific range of concentrations of the adsorption additive (surfactant) and selectivity in the Kaufman reference, including applicants' specifically claimed concentrations because the adsorption additives are considered to be equivalent for the purpose reducing the within-wafer-nonuniformity (WIWNU) of the wafers, thereby improving the surface of the wafer and reducing wafer defects (Kaufman, column 6, lines 52-55).

Applicants respectfully disagree with many of the above assertions. First, Kaufman explicitly specifies a concentration range for the adsorption additive (surfactant) in the slurry. Col. 6, line 45 to col. 7, line 12 of Kaufman is copied below for convenient reference:

In order to stabilize the first CMP slurry against settling, flocculation, and decomposition, a variety of optional CMP slurry additives, such as surfactants, stabilizers, or dispersing agents, can be used. If a surfactant is added to the first CMP slurry, then it may be an anionic, cationic, nonionic, or amphoteric surfactant or a combination of two or more surfactants can be employed. Furthermore, it has been found that the addition of a surfactant may be useful to reduce the within-wafer-non-uniformity (WIWNU) of the wafers, thereby improving the surface of the wafer and reducing wafer defects.

In general, the amount of additive such as a surfactant that may be used in the first CMP slurry should be sufficient to achieve effective stabilization of the slurry and will typically vary depending on the particular surfactant selected and the nature of the surface of the metal oxide abrasive. For example, if not enough of a selected surfactant is used, it will have little or no effect on first CMP slurry stabilization. *On the other hand, too much surfactant in the CMP slurry may result in undesirable foaming and/or flocculation in the slurry.* As a result, stabilizers such as surfactants should generally be present in the slurry of this invention in an amount ranging from about 0.001% to about 0.2% by weight, and *preferably from about 0.001 to about*

0.1 weight percent. Furthermore, the additive may be added directly to the slurry or treated onto the surface of the metal oxide abrasive utilizing known techniques. In either case, the amount of additive is adjusted to achieve the desired concentration in the first polishing slurry. Preferred surfactants useful in the first CMP slurry include dodecyl sulfate sodium salt, sodium lauryl sulfate, dodecyl sulfate ammonium salt, and mixtures thereof. Examples of preferred surfactants include TRITON DF-16 manufactured by Union Carbide, and SURFYNOL manufactured by Air Products and Chemicals. (*italics for emphasis only*)

Thus, although Kaufman discloses that the slurry can include one or more surfactants, as noted above, Kaufman's teaches that the surfactant is provided *only for stabilizing the slurry*. The surfactant concentration is taught to be sufficient for stabilization of the slurry, *while being low enough to "avoid undesirable foaming and or flocculation"*. The preferred surfactant concentration range is from about 0.001 to about 0.1 weight percent, and the maximum disclosed surfactant concentration of 0.2% by weight. These concentrations are generally orders of magnitude below 1 CMC. The only of the three (3) Kaufman examples (Example 3) which discloses a slurry including a surfactant includes 50 ppm of TRITON DF-16 which calculates to about .001 CMC.

Thus, Kaufman teaches away from using Applicants' claimed adsorption additive concentration range because the 0.2% by weight maximum concentration disclosed by Kaufman is taught as an upper limit. Above this concentration, Kaufman teaches that undesirable foaming and/or flocculation occurs. Such a concentration is below Applicants' claimed range and is generally an insufficient concentration to achieve micelle formation to realize the unexpected high CMP selectivity provided by the claimed selective adsorption additive in Applicants' claimed slurry.

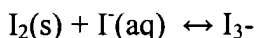
Thus, Kaufman does specify concentrations of the adsorption additive. One having ordinary skill in the art at the time the invention would not select *any* specific range of concentrations of the adsorption additive (surfactant) based on Kaufman's teaching of a maximum concentration of less than 0.2 wt % to avoid undesirable foaming and or flocculation.

Kaufman's desired result of reducing the within-wafer-nonuniformity (WIWNU) of the wafers is obtained using a fraction of this 0.2 wt % value, such as 50 ppm (Example 3). The other cited references do not make up for the above-described deficiencies regarding Kaufman. Since the claimed surfactant concentration range is outside Kaufman's disclosed surfactant range which is strongly bounded on the upper end by Kaufman's teaching of avoiding foaming and/or flocculation, Applicants submits that claim 2 recites an independently patentable limitation.

Some other claims also are believed to recite independently patentable limitations. The body of the Office Action provides no basis for rejection of Claim 8. Claim 8 (unchanged by the current Amendment) recites the slurry includes at least one species selected from the group consisting of a polyhalide ion, or the diatomic halogens I₂, Br₂ or F₂. As noted in Applicants'

March 1, 2004 Reply:

The term "halogen" is used in the application and is also well known in solution chemistry and refers to diatomic Group VIIA molecules, such as I₂, Br₂ or F₂. Halogens in solution generally produce characteristic colors to the solution, such as a purple color when Br₂ is present. The phrase "polyhalide ion" is also well defined in solution chemistry as a molecular ion including at least two Group VIIA species, the species not necessarily being different, such as I₃⁻. Although the term "polyhalide ion" is not disclosed in the application, it is well known in solution chemistry that the mixing of a halogen with a halide ion forms a polyhalide ion, such as:



Polyhalide ions can be contrasted with halide ions, which are also well defined and refer to monoatomic ions, such as F⁻, Cl⁻ and Br⁻. Halide ions are not known to impart color to a solution.

The recited polyhalide ion or halogen species reacts with metal films, such as copper or silver films, to form a soft layer on a surface of the film. The soft layer can be AgI, CuI, AgBr or CuBr, for example. Such metal halide layers are soft layers as they have a hardness less than that of the associated metal film. This facilitates a low defect CMP process, such as that obtainable using soft particles which have a hardness less than the metal layer being polished in the slurry.

The invention may be contrasted with conventional copper CMP slurries which include oxidizers, such as KIO₃ which form a copper oxide layer using the strongly oxidizing iodate ion (IO₃⁻). Specifically, a copper oxide (Cu₂O or CuO) layer is formed on the surface of the copper (or silver film) during the CMP process. Copper oxide (Cu₂O) is known to have a Mohs

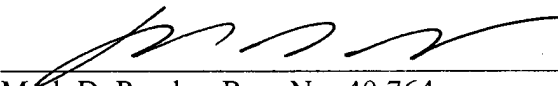
hardness of 3.5 to 4 and CuO to have a Mohs hardness of 3.5 to 4, which are both substantially greater than the Mohs hardness of copper films (2.5 to 3) or silver films, or common underlying dielectric layers such as silicon dioxide. Thus, the invention substantially overcomes problems associated with copper and silver CMP which relates to the need for abrasive particles to polish the hard oxide surfaces formed by the oxidizing species in the slurry. Specifically, the formation of a soft surface layer having a hardness less than the metal film, as opposed to a hard oxide film, permits a reduction in dishing, erosion, surface scratching, peeling, and also a reduction in the polishing of underlying layers.

Since no cited reference discloses or suggests addition of a polyhalide ion, I₂, Br₂ or F₂ to a slurry for CMP, Applicant submits that claim 8 recites independently patentable subject matter.

Applicants have made every effort to present claims which distinguish over the cited art, and it is believed that all claims are now in condition for allowance. However, Applicants request that the Examiner call the undersigned if anything further is required by the Examiner prior to issuance of a Notice of Allowance for all claims.

Respectfully submitted,

Date: November 3, 2004


Mark D. Passler, Reg. No. 40,764
AKERMAN SENTERFITT
222 Lakeview Avenue; Suite 400
P.O. Box 3188
West Palm Beach, FL 33402-3188
(561) 653-5000

Docket No. 5853-224